Peer Community In Ecology

Towards model-guided organic farming expansion for crop pest management

Sandrine Charles *based on peer reviews by* ***Lionel Hertzog***, ***Sylvain Bart*** *and* ***Julia Astegiano***

Thomas Delattre, Mohamed-Mahmoud Memah, Pierre Franck, Pierre Valsesia, Claire Lavigne (2023) Best organic farming deployment scenarios for pest control: a modeling approach. bioRxiv, ver. 1, peer-reviewed and recommended by Peer Community in Ecology. https://doi.org/10.1101/2022.05.31.494006

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Reduce the impact the intensification of human activities has on the environmental is the challenge the humanity faces today, a major challenge that could be compared to climbing Everest without an oxygen supply. Indeed, over-population, pollution, burning fossil fuels, and deforestation are all evils which have had hugely detrimental effects on the environment such as climate change, soil erosion, poor air quality, and scarcity of drinking water to name but a few. In response to the ever-growing consumer demand, agriculture has intensified massively along with a drastic increase in the use of chemicals to ensure an adequate food supply while controlling crop pests. In this context, to address the disastrous effects of the intensive usage of pesticides on both human health and biodiversity, organic farming (OF) revealed as a miracle remedy with multiple benefits. Delattre et al. (2023) present a powerful modelling approach to decipher the crossed effects of the landscape structure and the OF expansion scenario on the pest abundance, both in organic and conventional (CF) crop fields. To this end, the authors ingeniously combined a grid-based landscape model with a spatially explicit predator-pest model. Based on an extensive in silico simulation process, they explore a diversity of landscape structures differing in their amount of semi-natural habitats (SHN) and in their fragmentation, to finally propose a ranking of various expansion scenarios according to the pest control methods in organic farming as well as to the pest and predators' dissemination capacities. In total, 9 landscape structures (3 proportions of SHN x 3 fragmentation levels) were crossed with 3 expansion scenarios (RD = a random distribution of OF and CF in the grid; IP = isolated CF are converted; GP = CF within aggregates are converted), 4 pest management practices, 3 initial densities and 36 biological parameter combinations driving the predator' and pest's population dynamics. This exhaustive exploration of possible combinations of landscape and farming practices highlighted the main drivers of the various OF expansion scenarios, such as increased spillover of predators in isolated OF/CF fields,

increased pest management efficiency in large patches of CF and the importance of the distance between OF and CF. In the end, this study brings to light the crucial role that landscape planning plays when OF practices have limited efficiency on pests. It also provides convincing arguments to the fact that converting to organic isolated CF as a priority seems to be the most promising scenario to limit pest densities in CF crops while improving predator to pest ratios (considered as a proxy of conservation biological control) in OF ones without increasing pest densities. Once further completed with model calibration validation based on observed life history traits data for both predators and pests, this work should be very helpful in sustaining policy makers to convince farmers of engaging in organic farming.

References:

Delattre T, Memah M-M, Franck P, Valsesia P, Lavigne C (2023) Best organic farming deployment scenarios for pest control: a modeling approach. bioRxiv, 2022.05.31.494006, ver. 2 peer-reviewed and recommended by Peer Community in Ecology. https://doi.org/10.1101/2022.05.31.494006

Reviews

Evaluation round #1

DOI or URL of the preprint: https://doi.org/10.1101/2022.05.31.494006
Version of the preprint: 1

Authors' reply, 30 January 2023

Dear Sandrine Charles,

Thank you very much for the time spent reading and finding reviewers for our manuscript. We took into account all your comments and comments from the reviewers. We considerably refocused the manuscript by moving to supplementary material every result analysis that did not specifically address the comparison of expansion scenarios. We also added a general figure explaining the simulation study and numerous details about the population dynamics modelling and its relation to the real-world ecology of pests and predators. We hope that you will find that the changes improved the manuscript.

Detailed answers to every comment can be found attached. Please also note that the data repository has been updated to take into account some of the comments, and can now be found here: https://doi.org/10.5281/zenodo.7576542

Thank you again and best regards,

The authors

Download author's reply

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Decision by Sandrine Charles, posted 11 October 2022

Major revisions

Dear authors,

Based on the reviewers' comments, I ask you to resubmit your preprint after the consideration of the major issues raised by the reviewers. Some key points have been pointed out, for example the restructuration of your results and discussion parts, as well as more details about your modelling approach and the underlying hypotheses you chose. Two of the reviewers provided very detailed comments that should really help you

in improving your manuscript. So, please benefit from this in preparing a new version, that you will join to a point-by-point reply letter for me.

Best regards,

Sandrine Charles

Reviewed by Lionel Hertzog, 26 September 2022

In this manuscript Delattre et al explore the effect of organic farming expansion on pest and predator densities in virtual landscapes. The topic is timely given the upcoming expansion of organic farming and the uncertainty for practitionners regarding its potential drawbacks. The manuscript is generally well written and the results are interesting. I have the following major issues with the manuscript as it currently stands:

- parts of the discussion need to be expanded by comparing the results presented here with published empirical and modelling work. I am also missing a section in the discussion discussing the potential limitations of the simulated results presented here given the assumptions made in the model. For instance the results show situations with predator to prey ratios above one, this is contradictory to most empirical settings. Another example is the assumption that pesticide will affect pest but not predator.

- many results are presented: two different type of agricultural fields, within three different landscape context, for three different scenario of organic farming expansion, with four different pesticide effect for two different dispersal intensities ... I would argue to add at least one schematic overview figure summarizing the results. I also wonder whether to streamline the results, based on the aim of the manuscript, by focusing on the interaction between organic farming expansion (three scenarios) and landscape context (two level of fragmentation) and put the rest in appendices.

- the manuscript uses quite some abbreviations, I would recommend at the start of each section to fully name all terms before using the abbreviations.

In addition I have the following minor comments:

line 25: remove ”the”

line 47: cropping system sounds a bit too restrictive here, I would replace it with farming system.

line 71-72: by investigating the effect of OF on what? Please precise.

line 88: parenthesis around Petit can go away.

line 88: damage on what? Do you mean yield loss?

line 100-102: I would re-phrase the second part, something like: ”and may support higher spill-over of predators from seminatural habitats into agricultural fields”

line 121: I would re-phrase something like: ”lack of CBC data in the context of OF expansion”

line 142: de-capitalize intensity. Maybe better to use or add the word pesticide here?

line 152: please provide in the text or in appendices information on this model. Readers should not have to read another paper to know the basics of the model used here.

line 156: what is HSN?

line 169: error in formatting of the equation

line 165-182: I am not an expert of predator-prey LV models, but I find it curious that the effect of the prey on the predator growth is modelled separately from the predator growth function fp. I would have assumed that the function fp also takes as parameters the prey population and the interaction term. I am also not so sure what this interaction term represent, is this another way to specify the conversion efficiency of prey biomass into predator biomass? Could you cite some previous work that used a similar mathematical formulation of spatial predator-prey LV model? I also note that intrisic death rates as controlled by the parameters p are assumed to be solely driven by pesticides.

line 200-202: how could a pesticide having the same impact on pest species in conventional and OF fields have less or even no impact on predator in OF compared to conventional fields? These two scenarios looks like wishful thinking for me. Could you maybe back this up with empirical data showing that pesticides in OF fields have impacts on pests but not on predators?

Table 2: What is CF and BIO?

Figure 1: please use color-blind friendly color palette.

line 340-394: given that the aim of this manuscript is in studying predator-prey dynamics in the context of orgnaic farming extension, I find this paragraph to be beyond the scope. Consider reducing it or removing it.

line 406: this is interesting since my limited understanding of LV models is that they lead to a variety of dynamics from system collapse to stable periodicity. Please precise what you mean by stabilized (ie do you mean temporally constant densities?), at what spatio-temporal scale and provide some figures showing these stable dynamics.

Figure 4, 7 and 8: These figures are hard to interprete, they have multiple panels, different colors and line types. I would simplify and re-organize these figures to make the main results more readily stand out. For instance the text associated with figure 8 focus on the interaction between fragmentation and dispersion rates, figure 8 should then have one of these two variables in the x-axis with coloring for the second, patch area is not mentionned in the text associated with this figure so this variable can be averaged over.

line 516: which quartiles are represented in Figure 5?

Figure 5: predator to prey ratio seems extremely large, in organic fields with many SNH there were more predator individuals than preys. How do you explain this? And do you think that such a situation can occur in empirical systems?

line 519-521: convulated sentence, please re-formulate or split in two sentences.

Figure 7: please use the same typology of pesticide effects as in the method section.

line 569-570: the interactive effect of pest dispersal and fragmentation on pest densities appears marginal, the differences between fr=0.1 and fr=0.9 are low. These effects are also hard to see on figure 8, see my other comment.

line 590: at the start of each sections I would write again the full names of the abreviations, readers do not always read through from start to end but jump around.

line 601-602: Based on what results is this conclusion based?

line 602: To what does the this refers to? To your results that IP provide most benefits for biological control or to the fact that organic farming extension mostly happens in patterns similar to your IP scenario? I would rephrase this sentence and the next to make it clear.

line 612: densities of what?

line 614: SNH can be dropped.

line 621: predator to pest ratio

line 622: Aha, if the benefits that you mentionned at the beginning of the discussion section refers to the predator to pest ratio as a proxy for biological control then this should be stated also there.

line 625: using random development as a baseline seems odd especially since you mentionned a few lines above that in real landscapes organic farming expansion rather follows a clustered pattern. So either use IP scenario as baseline (what would happen if OF expansion follows the current trend) or discuss why you think that using random development is better suited as a baseline for this exercice.

line 629: use throughout the same wording for the predator to pest ratio.

line 631-647: A complex paragraph again focusing on land-use development a bit beyond the focus of this manuscript. I would recommend to remove it.

line 645-646: Do you mean that you assume to be able to predict how pest and predator dynamic will be in a given landscapes based on the results presented here? This sounds overconfident, especially given that your results showed interactive effects with landscape contexts.

line 664: What strategies?

line 669-673: I don't get these sentences first you write that IP is best for predator to pest ratio and then you write that under this strategy it declines. Harmonize the two sentences.

line 682-684: A very clear sentence, I would start the paragraph (line 669) with this one and develop from it.

line 716: What is meant by intensive organic farming?

line 662-754: There is little comparison of the results presented here with already published work. Please reflect on how the results presented here complement, contradict or present new results compared ot past empirical and modelling work.

line 755: In the conclusion I would use a term less cold than IP strategy, maybe replacing it by ”clustered organic farming expansion”.

Online repository: The model code on the OSF repository would profit from a fully fledged readme explaining how to run the models and either describing the main features of the models or citing the relevant literature. The zenodo repository is very large (1Gb), I would only put on the repository the post-processed datasets used to draw the figures, the raw data files of 500Mb are not needed there. The zenodo repository would also benefit from a readme file explaining what the code is doing.

Reviewed by Julia Astegiano, 30 September 2022

Dear Sandrine Charles,

Many thanks for the invitation to review this manuscript. After reading carefully this work, I found it very interesting and I think it represents a great contribution to discussions about how to advance with sustainable agricultures. In general terms, the manuscript is very well introduced and methods are precisely described, but results and discussion sections need to be reorganised, with great emphasis on the main objectives of the article. Moreover, including explanatory figures describing the modeling process and scenarios evaluated will certainly allow the manuscript attain a wider public. I made numerous comments and suggestions to the authors in the original manuscript. I attach the commented version and I hope that my review helps improving the manuscript.

Best,

Julia Astegiano

Download the review

Reviewed by Sylvain Bart, 14 September 2022

This manuscript presents a valuable and innovative approach to explore best organic farming deployment scenarios for pest control. It helps to understand how spatial strategies of organic farming deployment impact conservation biological control. The manuscript is well written and organised, methods are clearly explained and results well-presented and discussed. They are a lot of results but the result and discussion section are well organised to account for it.

I miss a paragraph (will probably fit at the end) about the limitation of the modelling approach, and the weight of the choices made in the construction and hypothesis formulated in the model. For instance;

line 193-195: This is an important choice that may affect the output of the model, what is the rational for this choice? I would suggest authors to add more explanation regarding this choice. Is it base on actual predator life history traits? My first thought was predator do not reproduce during the winter because they don’t have resources to do so.

The conclusion regarding this modelling approach is interesting but caution should be taken because it is not based on actual life history traits of a prey-predator couple. A nice perspective would be to run the model with observed data regarding the life history traits of a prey and a predator (precise season of activity, etc...)

A discussion on that matter would longer the discussion part, which is already a bit long, but I think the other parts might be shortened